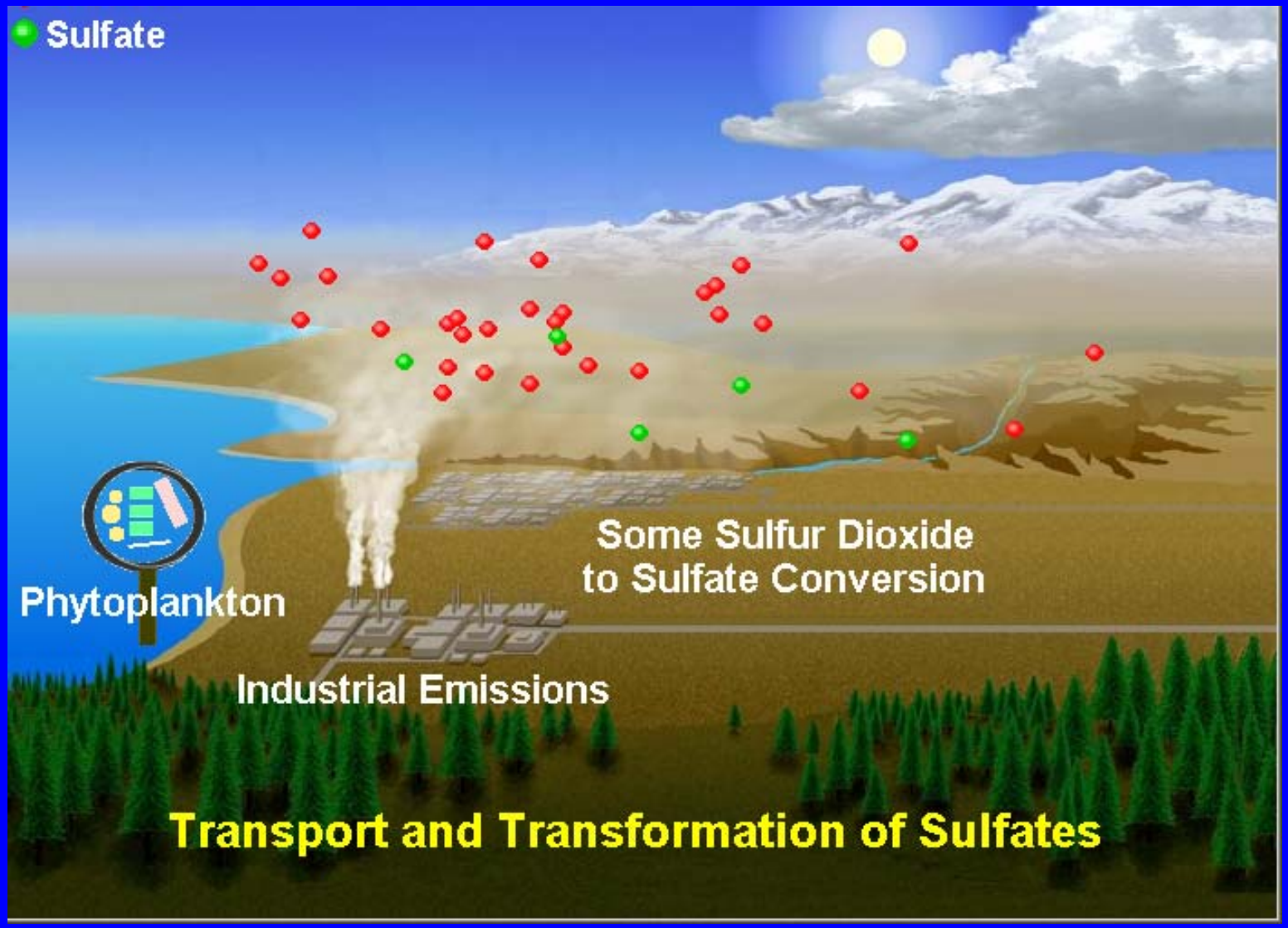
Causes of Haze

Source Receptor Relationship

Receptor Concentration	=	Dilution	*	Chemistry/ Removal	*	Emissions

Optical properties = f(aerosol concentration,
composition
size
shape)

Transport, Transformation and Removal

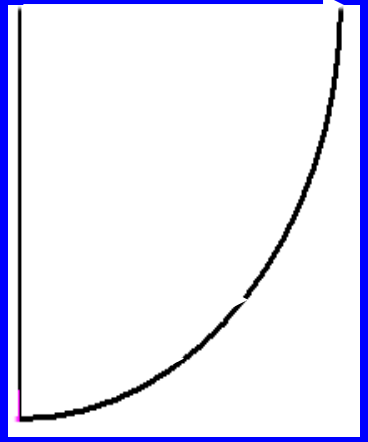


Regional Scale Dispersion Processes

Day Time Mixing
Random Mixing

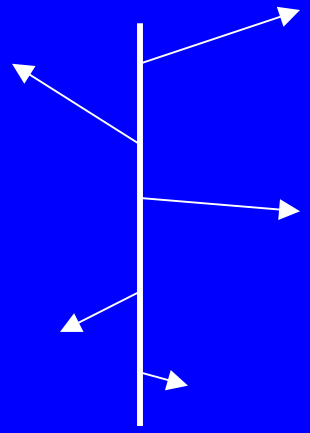
Vertically distributes pollutants

Wind Shear
Axial Mixing



Horizontally Spreads pollutants

Wind Veer
Axial Mixing



Horizontally redistributes pollutants

The three transport processes that shape regional dispersion are wind shear, veer, and eddy motion or random mixing. Homogeneous hazy airmasses are created through shear and veer at night followed by vigorous vertical mixing during the day.

Visibility Indices

Commonly Used Visibility Indices

- Light extinction coefficient
  - Index of choice for air quality scientist because of its relationship to pollutant concentrations
- Visual range
  - Most commonly used and misunderstood index by the non-scientists, property of aerosols along site path.
- Haziness in deciview units
  - Newest index designed so that equal deciview changes represent nearly equally perceptible haze changes over the full range of conditions

Light Extinction Coefficient

- The fractional attenuation of light per unit distance is known as the light extinction coefficient or b_{ext}
  - Fundamental property of gases and particles
  - Light extinction coefficient units are one over length, for example inverse kilometer (km^{-1}) or inverse megameters ($Mm^{-1} * 1000 = km^{-1}$)
  - Light extinction coefficient is the only index that is the sum of its component parts, e.g. species, source contributors, etc. (Strictly true for externally mixed aerosol components).

Visual Range

- Observer meteorological range is the greatest distance that large dark objects can be seen - no longer used by the NWS
- Visual range is the extinction based index designed to estimate meteorological range

Visual Range

- Visual Range is defined as

$$V = 3912/b_{ext}$$

  - Visual range in kilometers and extinction in Mm^{-1}
  - Assumes threshold contrast of 0.02
  - Assumes uniform lighting and atmosphere
  - Assumes large black target against the sky
  - Assumes flat earth
  - Assumptions are not well met under low haze conditions (e.g. visual range > 50km)

Haziness in Deciview Units

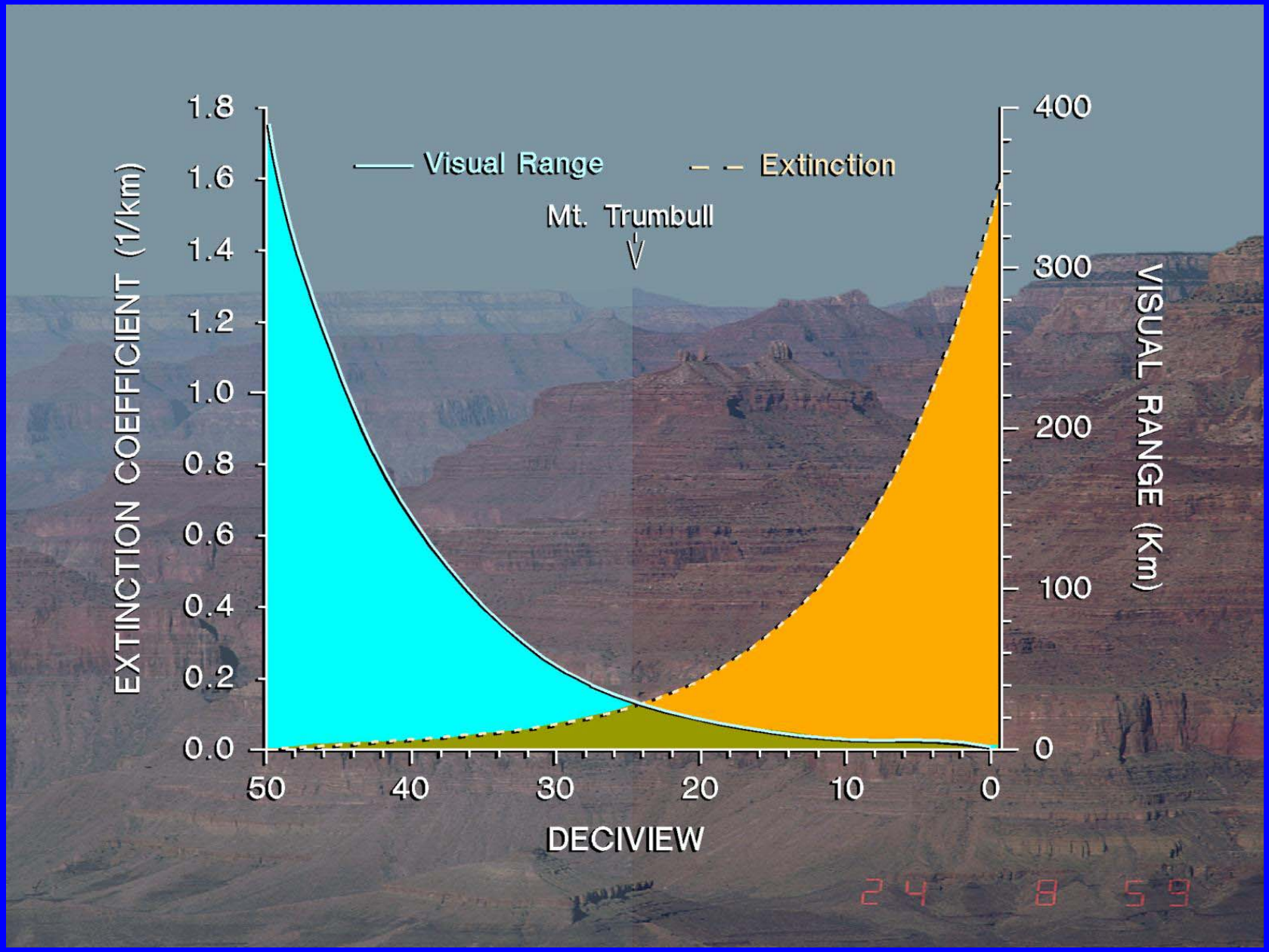
- Haziness measured deciview units is analogous to sound measured in decibel units in that they are both logarithmic transformation to produce perceptually linear parameters
- Haziness is defined by

$$\text{Haziness (dv)} = 10\ln(b_{ext}/10)$$

  - for b_{ext} in Mm^{-1}

Haziness in Deciview Units

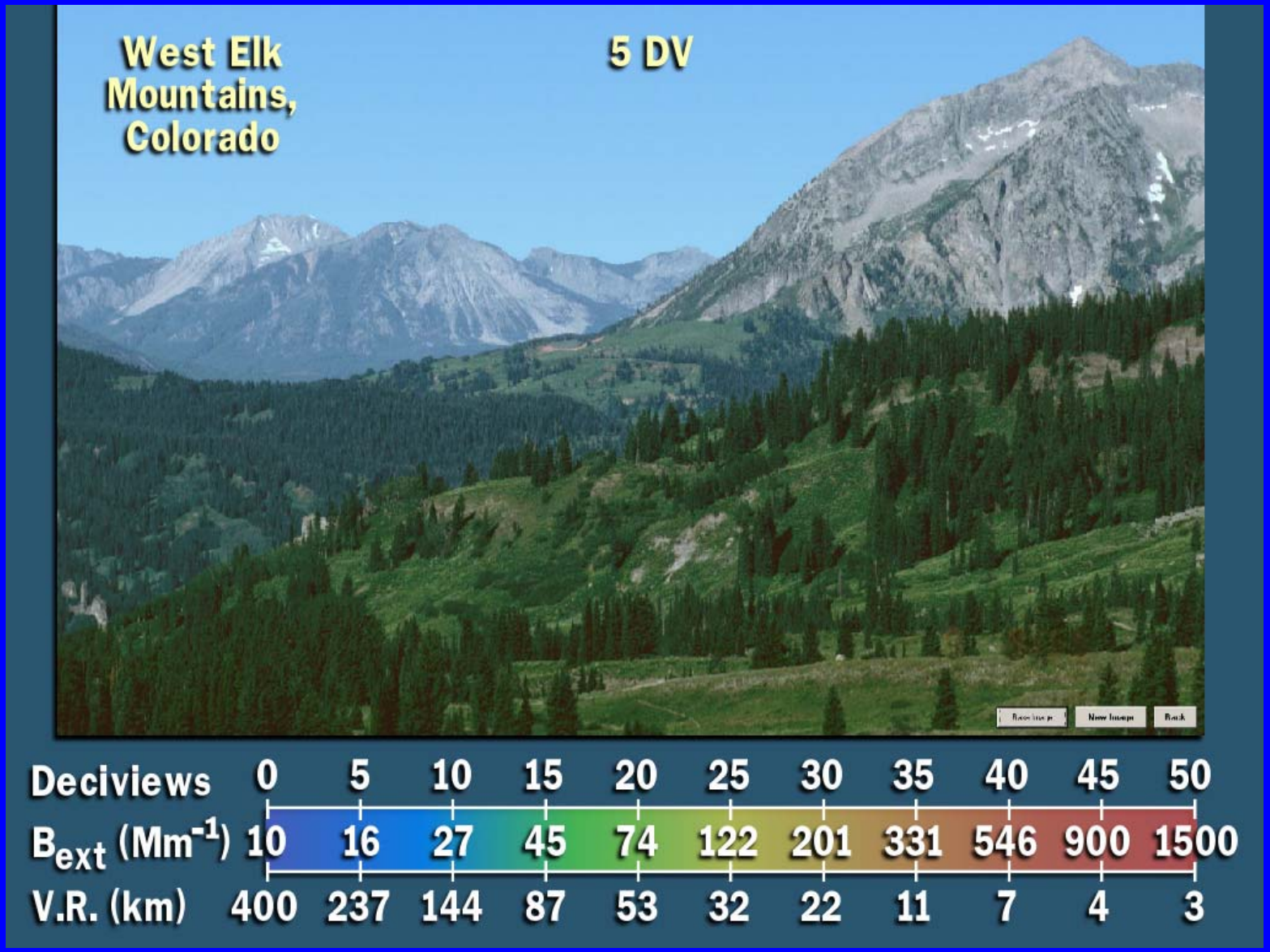
- 1 dv increment = 10% change in b_{ext}
  - a small but often perceptible change in haze if the scene includes features near the visual range
- 0 dv = $10Mm^{-1}$; Rayleigh Scattering
- Visibility data expressed in deciview have a nearly normal distribution so simple statistics are appropriate


Visual Range
Extinction
Mt. Trumbull
EXTINCTION COEFFICIENT (1/km)
VISUAL RANGE (Km)
DECIVIEW
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
400
300
200
100
0
50
40
30
20
10
0

WinHaze
"A Picture is Worth 1000 Words"

- WinHaze Freeware available at http://vista.cira.colostate.edu/improve/Tools/win_haze.htm
  - Computer-imaging software program that simulates visual air quality differences of various scenes on your PC
  - Select from 57 national parks, wilderness, & urban areas
  - Input the haze level or particle species concentrations
  - View effects of changed haze levels on separate images or split screen

Relationship of Haze Indices & a WinHaze Scenic Photograph



Relationship of Perceptible Changes to Haze Indices